International Civil Aviation Organization

AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST SEMINAR AND TWELFTH MEETING OF AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) STUDY AND IMPLEMENTATION TASK FORCE (ADS-B SITF/12)

Kolkata, India, 15-18 April 2013

Agenda Item 6: Review States' activities and interregional issues on trials and implementation of ADS-B and multilateration

SINGAPORE'S EXPERIENCE ON THE ADS-B SAFETY ASSESSMENT

(Presented by Singapore)

SUMMARY

This paper shares with the Task Force the progress made by Singapore on the safety assessment for ADS-B operations in Singapore FIR as well as the challenges.

1. Introduction

1.1 Singapore has scheduled to provide ADS-B services within parts of Singapore FIR at the end of 2013. As part of the safety management process, we are now generating the safety assessment.

1.2 This paper serves to share with the Task Force on the approach adopted by Singapore and the challenges faced in producing the safety case.

2. Approach Adopted

2.1 Singapore adopted the approach whereby we drafted safety assessment based on the approach adopted by this Task Force and invite a consultant to perform a peer review to ensure that it is harmonized with the best practices worldwide.

2.2 During the initial phase of the implementation of ADS-B services, Singapore will only provide ADS-B exclusive services over the areas as stated in **Annex A**, which is effectively ADS-B-NRA. However, in draft safety assessment, the entire FIR is covered, including ADS-B-RAD and the non-radar areas currently not yet covered by ADS-B. The areas currently not covered by ADS-B were assessed as ADS-B-NRA, based on the assumption that eventually, they would be covered by ADS-B. Hence the draft assessment covered both ADS-B-NRA and ADS-B-RAD.

2.3 At this moment, the consultant has provided their initial findings on the draft safety assessment. The review was largely based on the safety standards, requirements and assumptions detailed in the following documents:

a) Eurocontrol's Preliminary Safety Case for Enhanced Air Traffic Services in Non-Radar Areas using ADS-B surveillance (PSC ADS-B-NRA);

b) Eurocae and RTCA's Safety, Performance and Interoperability Requirements Document for ADS-B-NRA Application (ED-126 / DO-303);

c) Eurocontrol's Preliminary Safety Case for Air Traffic Control Service in Radar Areas using ADS-B Surveillance (PSC ADS-B-RAD); and

d) Eurocae and RTCA's Safety, Performance and Interoperability Requirements Document for ADS-B-RAD Application (ED-161/ DO-318).

3. Initial Comments From Consultants

3.1 There were several comments from the consultant. Only the more challenging comments are discussed here. The comments for ADS-B-NRA are listed in **Annex B**. The comments for ADS-B-RAD are listed in **Annex C**. Based on the comments by the consultants, we have great difficulty implementing ADS-B-RAD.

3.2 Separately, we may insist on applying the requirements (for both ADS-B-NRA and ADS-B-RAD) stated by ICAO Cir326. According to ICAO Cir326, the requirements are as follows

Characteristic	Minimum Requirement for 3 NM Separation	Minimum Requirement for 5 NM Separaion
Position: Accuracy	A 95 percentile accuracy of 0.3 NM This can be represented by either: a) NAC ≥ 6; or b) NUC ≥ 5	A 95 percentile accuracy of 0.5 NM This can be represented by either: a) NAC ≥ 5; or b) NUC ≥ 4
Position: Integrity	A containment radius of <1 NM and the likelihood of the position error exceeding containment radius of 1×10^{-5} This can be represented by either: a) NUC ≥ 4 ; or b) NIC ≥ 5 and SIL ≥ 2	A containment radius of <2 NM and the likelihood of the position error exceeding containment radius of 1×10^{-5} This can be represented by either: a) NUC ≥ 3 ; or b) NIC ≥ 4 and SIL ≥ 2
Position: Latency	4 seconds	4 seconds
Position: Update Rate	5 seconds	12 seconds

3.3 While traffic density is not a consideration in Cir 326, Cir 326 does mention that the assessment was done based on low complexity airspace. While the Task Force previously discussed that complexity of airspace does not prevent the use of the implementation of ADS-B-RAD, it's good to review now, whether Asia Pacific should continue to adopt Cir326 or other standards for ADS-B-RAD.

3.4 Nevertheless, regardless whether ADS-B-RAD can be applied, Singapore and the consultant are looking into the safety impact of introducing ADS-B tracks into the multi-surveillance tracker of the air traffic control automation system, without any reduction of separation under multi-sensor environment. In this case, the ADS-B tracks will only serve to improve the accuracy and the update rate of the multi-surveillance tracks.

4. Action by the Meeting

4.1 The meeting is invited to:

a) note the progress on the safety assessment; and

b) to review the performance required for the application of ADS-B-RAD in Asia Pacific.

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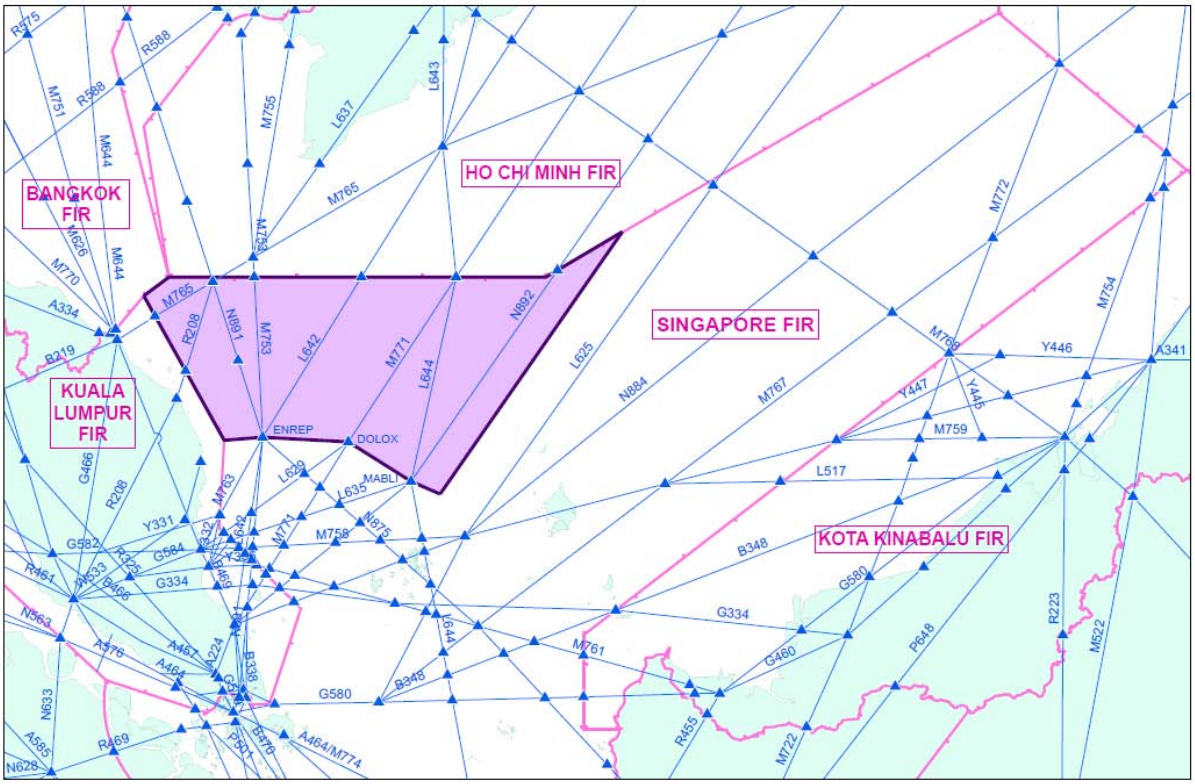
Annex A

AREAS WHERE ADS-B SEPERATION WILL BE IMPLEMENTED



Annex B

COMMENTS FROM CONSULTANTS ON ADS-B-NRA

The consultant recommended that the performance of the ADS-B system be verified against those stated in ED-126 such as the following:

ADS-B-NRA performance for en-route 5NM separation			To meet requirement	Assessment on impact to operations
Update rate	for Surveillance Position report (including change in quality indicators) - equivalent to radar scan	≤ 10s	Fulfilled when meet AMC20-24	No problem
	For Surveillance report containing any new aircraft Identity (aircraft identification / Mode A code, 24 bits address) associated with any single aircraft.	≤ 100s	Fulfilled when meet AMC20-24	No problem
	for Surveillance Emergency/SPI change	≤ 10s	Fulfilled when meet AMC20-24	No problem
Update probability	for Surveillance Position report (same as for radar target)	≥0.95	Fulfilled when meet AMC20-24 and within good coverage	No problem
	for Surveillance Identity change (aircraft identification / Mode A code & 24 bits address)	≥0.95	For aircraft ID change, fulfilled when meet AMC20-24 and within good coverage. For mode A require DO-260A and DO-260B.	No problem for aircraft ID, but mode A may not be available.
	for Surveillance Emergency /	≥0.95	Fulfilled when	No problem

	SPI change		meet AMC20-24 and within good coverage	
Horizontal Position Accuracy	Horizontal Position Accuracy 95%	<0.5Nm	Fulfilled when meet AMC20-24 and necessary GNSS availability	No problem
Horizontal Position Integrity	Quality Indicators	NIC≥4 or NUC≥4	Fulfilled when meet AMC20-24 and necessary GNSS availability	No problem
	Position source failure probability	10^{-4}/h	Fulfilled when meet AMC20-24	No problem
	Position source alert failure probability	10^{-3}	Fulfilled when meet AMC20-24	No problem
	Time to alert	10s	Fulfilled when meet AMC20-24	No problem
Latency	Maximum latency for surveillance position, identification and Emergency/SPI data at input of ATC System	2s	If based on AMC20-24, after 1.5s of latency, only 0.5s is available for VSAT comms.	Minimum NUC may need to be increased
Time Stamp	Maximum timestamp inaccuracy	0.2s	Met by ground station	No problem

COMMENTS FROM CONSULTANTS ON ADS-B-RAD

The consultant recommended that the performance of the ADS-B system be verified against those stated in ED-161 such as the following:

ADS-B-RAD Performance at input of ATC system		En-route (5NM)	TMA (3NM)	Final Approach (2.5NM)	To meet requirement	Assessment on impact to operations
Update interval	for State Vector (state vector information including change in quality indicators)	≤ 8s	≤ 5s	≤ 5s	Fulfilled when meet AMC20-24	No problem
	for Identity (aircraft identification and Mode A code)	≤ 8s	≤ 5s	≤ 5s	Fulfilled when meet AMC20-24	No problem
	for Surveillance Emergency and SPI	≤ 8s	≤ 5s	≤ 5s	Fulfilled when meet AMC20-24	No problem
Update probability	For State vector	≥0.97	≥0.97	≥0.97	Fulfilled when meet AMC20-24 and within good coverage	No problem
	for Identity (aircraft identification / Mode A code & 24 bits address)	≥0.95	≥0.95	≥0.95	For aircraft ID change, fulfilled when meet AMC20-24 For mode A require DO-260A and DO-260B.	No problem for aircraft ID, but mode A may not be available.
	for Surveillance Emergency / SPI change	≥0.95	≥0.95	≥0.95	Fulfilled when meet AMC20-24 and within good coverage	No problem
Horizontal Position Accuracy	Horizontal Position Accuracy 95%	NAC≥7	NAC≥8	NAC≥8	Only for DO-260A and above.	For DO-260, we may use the NUC to derive the HPA.
Accuracy Vertical	Altimeter accuracy	125ft	125ft	125ft	Fulfilled when	No problem

ADS-B-RAD Performance at input of ATC system		En-route (5NM)	TMA (3NM)	Final Approach (2.5NM)	To meet requirement	Assessment on impact to operations
Position					meet AMC20-24	
Vertical Position Resolution	Resolution in Mode C	≤ 100ft	≤ 100ft	≤ 100ft	Fulfilled when meet AMC20-24	No problem
Horizontal Position Integrity	Quality Indicators	NIC≥5	NIC≥6	NIC≥7	Only for DO-260A and above.	For DO-260, we may use the NUC to derive the NIC.
	SIL	SIL=3	SIL=3	SIL=3	Only for DO-260A and above.	Cannot be met by DO-260.
Latency	Maximum latency for surveillance position, identification and Emergency/SPI data at input of ATC System	2s	2s	2s	If follow AMC-20-24, after 1.5s of latency, only 0.5s is available for VSAT comms.	Minimum NUC may need to be increased
Time Stamp	Maximum timestamp inaccuracy	0.1s	0.1s	0.1s	Met by ground station	No problem

Transmitting Aircraft Domain ADS-B-RAD Performance		En-route (5NM)	TMA (3NM)	Final Approach (2.5NM)	To meet requirement	Assessment on impact to operations
Horizontal Position Accuracy	Horizontal Position Accuracy 95%	NAC≥7	NAC≥8	NAC≥8	Only for DO-260A and above.	For DO-260, we may use the NUC to derive the HPA.
Accuracy Vertical Position	Altimeter accuracy	125ft	125ft	125ft	Fulfilled when meet AMC20-24	No problem
Vertical Position Resolution	Resolution in Mode C	≤ 100ft	≤ 100ft	≤ 100ft	Fulfilled when meet AMC20-24	No problem
Horizontal Position Integrity	Quality Indicators	NIC≥5	NIC≥6	NIC≥7	Only for DO-260A and above.	For DO-260, we may use the NUC to derive the NIC.
	Position source failure probability	10^{-4}/h	10^{-4}/h	10^{-4}/h	Fulfilled when meet AMC20-24	No problem
	Position source alert probability	10^{-3}(per position source failure event)	10^{-3}(per position source failure event)	10^{-3}(per position source failure event)	Fulfilled when meet AMC20-24	No problem
	Time to alert	10s	10s	10s	Fulfilled when meet AMC20-24	No problem
	The time between a change in satellite reception status in the GNSS receiver and the delivery of the resulting integrity quality indicator change	<2s	<2s	<2s	Fulfilled when meet AMC20-24	No problem
Latency	The ADS-B Transmitting Aircraft Domain shall have a 95% total latency of 1.5s or less for surveillance position, quality indicators, identification and Emergency /	<1.5s	<1.5s	<1.5s	Fulfilled when meet AMC20-24	No problem

Transmitting Aircraft Domain ADS-B-RAD Performance		En-route (5NM)	TMA (3NM)	Final Approach (2.5NM)	To meet requirement	Assessment on impact to operations
	SPI data					
	95% uncompensated latency for horizontal position	<0.6s	<0.6s	<0.6s	Only for DO-260A and above.	Cannot be met by AMC20-24 and DO-260. Minimum NUC may need to be increased
	99.9% maximum uncompensated latency for horizontal position	<1s	<1s	<1s	Only for DO-260A and above.	Cannot be met by AMC20-24 and DO-260 Minimum NUC may need to be increased